BIOLOGICAL EVALUATION OF GYPSY MOTH

at

ANDREWS AIR FORCE BASE

2007

Prepared by
Rodney L. Whiteman
Forester

USDA Forest Service
Forest Health Protection
Morgantown, WV 26505

October 2007

ABSTRACT

On September 19, 2007, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Andrews AFB. The purposes of this survey were to determine population densities, assess the potential for defoliation and the need for treatment in 2008. Current populations are sufficient to cause heavy defoliation on 215 acres in 2008. Treatment is recommended to prevent defoliation and possible tree mortality.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (2007) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre Egg mass lengths were also measured at the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity.

RESULTS

The location of the survey plots are shown in Figure 1. The summarized results are presented in Table 1. In brief, egg mass densities at Andrews Air Force Base (AFB) ranged from 0-12,680 and averaged 1568 egg masses per acre. Overall egg mass lengths tended to be moderate to large in size, ranging from 20-46 mm and averaging 32 mm. High gypsy moth population levels were found around the golf course, a small woodlot in the south eastern portion of the base that is dissected by East Perimeter Road and a portion of a woodlot along the north eastern boundary of the base. Egg mass densities in these areas averaged 3276 per acre with an average size of 32 mm.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include; previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (30-50 percent); or heavy (51-100 percent). Defoliation less than 30 percent has little impact on trees and can not be detected through an aerial survey.

The egg mass survey results indicate that heavy defoliation is likely to occur in three areas totaling approximately 215 acres at Andrews AFB in 2008 (Figure 2).

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 3 shows how this information can be used to correlate the predicted defoliation of an area.

Accordingly, the estimated egg mass density of 3331 egg masses per acre (average egg mass density in the area around the golf course) x 31 mm (average egg mass length in the area around the golf course) translates to a projected defoliation level of about 78 percent (heavy defoliation). Because egg mass densities and the host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominantly heavy throughout this area of Andrews AFB. Heavy defoliation is also expected in the woodlot dissected by East Perimeter Road and a portion of a woodlot along the northeastern boundary of the base. No defoliation is expected elsewhere at Andrews AFB in 2008.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy throughout most areas surveyed at Andrews AFB. The average egg mass length is 31 mm. Egg masses larger than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. There was no evidence that either one of these entomopathogens had significant impacts at Andrews AFB in 2007. Although it is still possible that either the gypsy moth fungus or the NPV could cause the general collapse of the gypsy moth population next year, it is unlikely that populations will collapse prior to a significant defoliation event occurring in 2008.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light defoliation (<50 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Individual and small groups of trees were defoliated by gypsy moth at Andrews AFB in 2007. Also, Andrews AFB experienced droughty conditions during the 2007 growing season.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak saw timber and 14 percent of the total oak pole timber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

Based on observations of the existing health of the trees at Andrews AFB and the factors mentioned above, areas of tree mortality are expected if defoliation occurs. Mortality will be more prevalent if adequate rainfall is not received during the 2008 growing season and or defoliation occurs on the same trees that were defoliated in 2007.

Management Options

In 2008, three management options have been evaluated for managing gypsy moth populations at Andrews AFB. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent branch dieback and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating levels of gypsy moth populations, viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels.

Although it is not possible to accurately assess such events with the defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations information at hand, it is unlikely that a collapse will occur in 2008 since most of these areas are newly infested and there is an abundance of large healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al., (1996) showed short-term impacts of both species richness and abundance occurred following light defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that heavy defoliation will occur in the three areas of Andrews AFB depicted in Figure 2.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al., (1996) in West Virginia. Miller's study involved a large scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1 year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½ -1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 4×10^{11} occlusion bodies (OB's) per acre applied in a single application or 2×10^{11} OB's per acre applied in a double application. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There are, however, sufficient quantities of Gypchek currently available for 2008 should this insecticide be preferred for use at Andrews AFB.

Chemical Insecticide Option

The third option is to use a chemical insecticide to control gypsy moth populations. There is currently one chemical insecticide registered for control of gypsy moth populations and approved by the USDA Forest Service for use in cooperative gypsy moth control programs.

Dimilin® (diflubenzuron) is the most widely used chemical insecticide in gypsy moth suppression projects in the U.S. and is registered by the EPA for use in residential areas. Diflubenzuron (DFB) is an insect growth regulator that disrupts the normal molting processes of the larvae. The mode of action is to inhibit the formation chitin, a necessary component of the outer cuticle which causes the affected larvae to die during the molt following treatment. The method of uptake is primarily by ingestion, however some research has indicated the possibility of absorption through the cuticle as well. DFB is relatively persistent on foliage (24 days) which increases the efficacy on gypsy moth populations but also exposes non-target insects, particularly caterpillars, for a greater period of time.

DFB is extremely toxic to some aquatic invertebrates and the label prohibits the application over open water or wetlands. DFB is available as an oil based liquid formulation (Dimilin® 4L) and is normally applied in a single application at the standard rate of 1-2 ounces of formulated material per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Alternatives

With the previously described options in mind, the following alternatives are offered:

Alternative 1. - No action.

Alternative 2. - One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.

Alternative 3. - Two aerial applications of *Btk*, as in alternative 2, applied 4-7 days apart.

Alternative 4. - One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre.

Alternative 5. - Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

Alternative 6. - One aerial application of DFB at the rate of 1.0 oz formulated material in a total mix of 1 gallon per acre.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient at Andrews Air Force Base to cause heavy defoliation on 215 acres in 2008. To protect tree foliage and prevent subsequent tree mortality, our recommendation is alternative 6 (a single application of DFB).

This recommendation is based on the following considerations:

1) A single application of diflubenzuron is likely to provide both better foliage protection and greater gypsy moth population reduction than either Btk or Gypchek.

2) It is also a more economical choice than either Btk or Gypchek.

3) There are no open bodies of water or wetlands in any of the three proposed treatment areas that would prohibit its use.

4) If Andrews AFB is opposed to using a chemical application to control this gypsy moth infestation, we would recommend alternative 3 (a double application of Btk). However, this option would cost at least twice the amount of option 6 and an aerial applicator would have to commit an aircraft for two days spaced 4-7 days apart instead of just a single day. A majority of applicators may not want to make this commitment for the small amount of acres involved.

REFERENCES

Allegheny National Forest, Warren, PA. 1998. Gypsy moth caused oak mortality – Allegheny National Forest, 1988. USDA Forest Service internal report prepared by Forest Pest Management staff, Morgantown, WV. Unp.

Gottschalk, K.W. 1990. Gypsy moth impacts on mast production, *In*: McGee, Charles E. Ed. Proceedings of the Workshop, southern Appalachian Mast Management; 1989 August 14-16; Knoxville TN; University of Tennessee; 42-50.

Liebhold, A.M., Simons, E.E., Sior, A., and Unger, J.D. 1993. Forecasting defoliation caused by the gypsy moth from field measurements. Environ. Entomol. 22(1): 26-32.

Miller, J.C. 1990. Field assessment of the effects of a microbial pest control agent on non-target Lepidoptera. American Entomologist 36:2, 135-139.

Moore, K.E.B. and Jones, C.G. 1987. Field estimation of fecundity of gypsy moth (Lepidoptera: Lymnatriidae). Environ, Entomol. 16: 165-167.

Sample, B.E., Butler, L., Zivkovich, C., Whitmore, R.C., and Reardon, R.C. 1996. Effects of *Bacillus thuringiensis* Berliner var. *Kurstaki* and defoliation by gypsy moth [*Lymantria dispar* (L.) (Lepidoptera: lymnatriidae)] on native arthropods in West Virginia. The Canadian Entomologist 128:573-592.

West Virginia Division of Forestry. 1997. *In* 1997 Cooperative State-County-Landowner Gypsy Moth Suppression Program in West Virginia. 3p. (Brochure).

Table 1 – Gypsy moth egg mass survey results at Andrews Air Force Base
September 19, 2007

Plot #	# em/acre	em size (mm)
1	0	—
2	0	—
3	0	—
4	80	30, 32
5	0	—
6	0	—
7	0	—
8	0	—
9*	1160	32, 42, 38
10*	360	42, 26
11	120	30
12	0	—
13	0	—
14*	13,680	24, 20, 24
15*	6960	30, 40, 28
16*	1160	34, 32, 32
17*	1640	42. 30, 32
18*	5840	26, 32, 30
19*	2320	32, 30, 22
20	120	28
21*	2200	30, 32, 30
22*	280	28
23	80	—
24*	160	30, 36
25	0	—
26*	9840	20, 30, 36
27*	280	—
28*	760	26
29	0	—
30	0	—
31	0	—
32*	2760	30, 32, 32
33*	2520	46, 32, 32
34*	1120	—
35	0	—
36	40	—

Table 1 – (continued)

Plot #	# em/acre	em size (mm)
37*	2680	32,30,30
38	40	—
39	0	—
40*	6520	42, 30, 26

em/acre range = 0-13,680 em size range (mm) = 20-46
em/acre average = 1568 em size average (mm) = 31

*= located in proposed treatment area
em/acre range in proposed treatment areas = 160-13,680
em/acre average in proposed treatment areas = 3276
em size range in proposed treatment areas (mm) = 20-46
em size average in proposed treatment areas (mm) = 32

Figure 1. -- Gypsy moth egg mass survey plot locations at Andrews Air Force Base, September 19, 2007.

Figure 2. -- Area where defoliation is likely in 2008/Proposed treatment areas at Andrews Air Force Base.

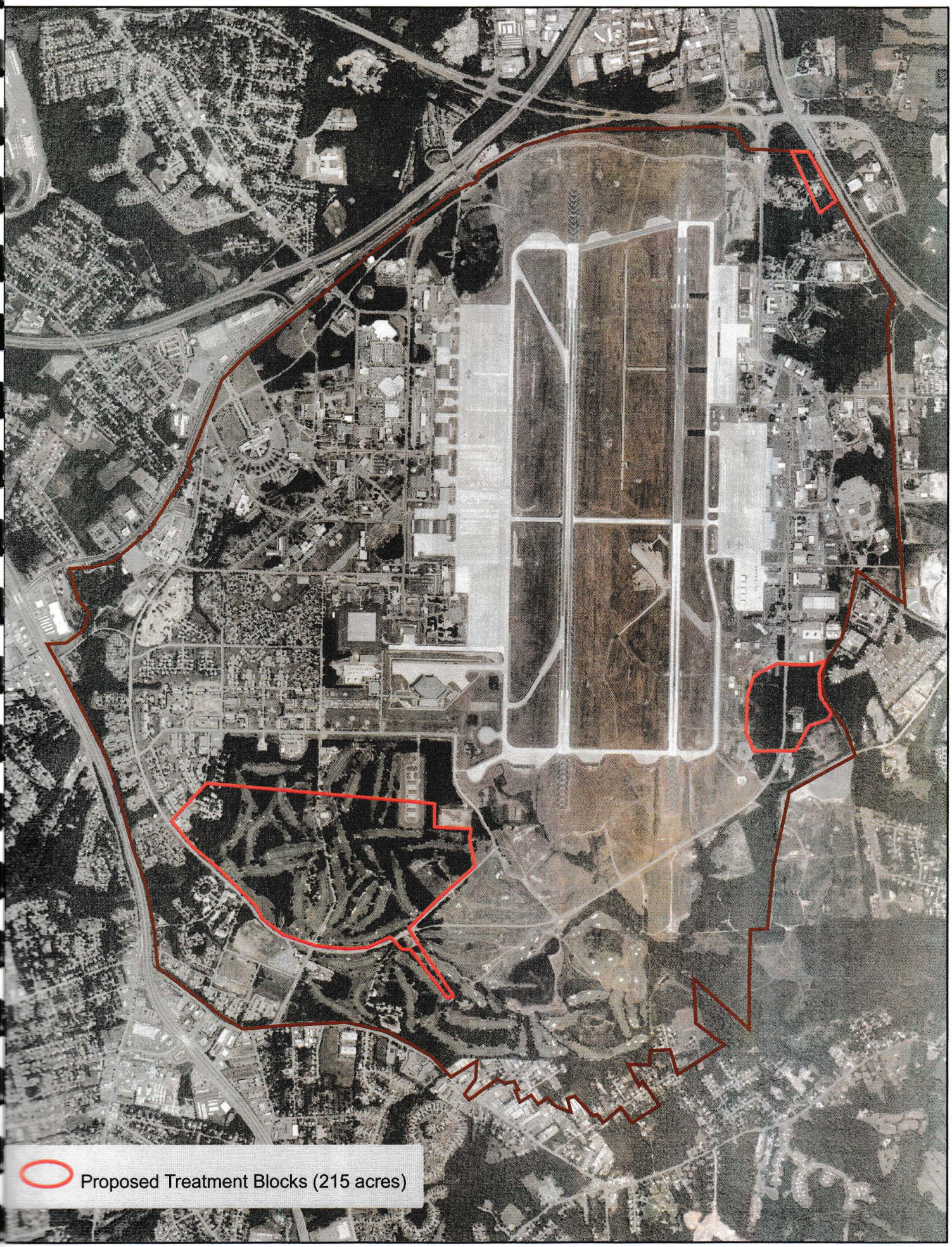
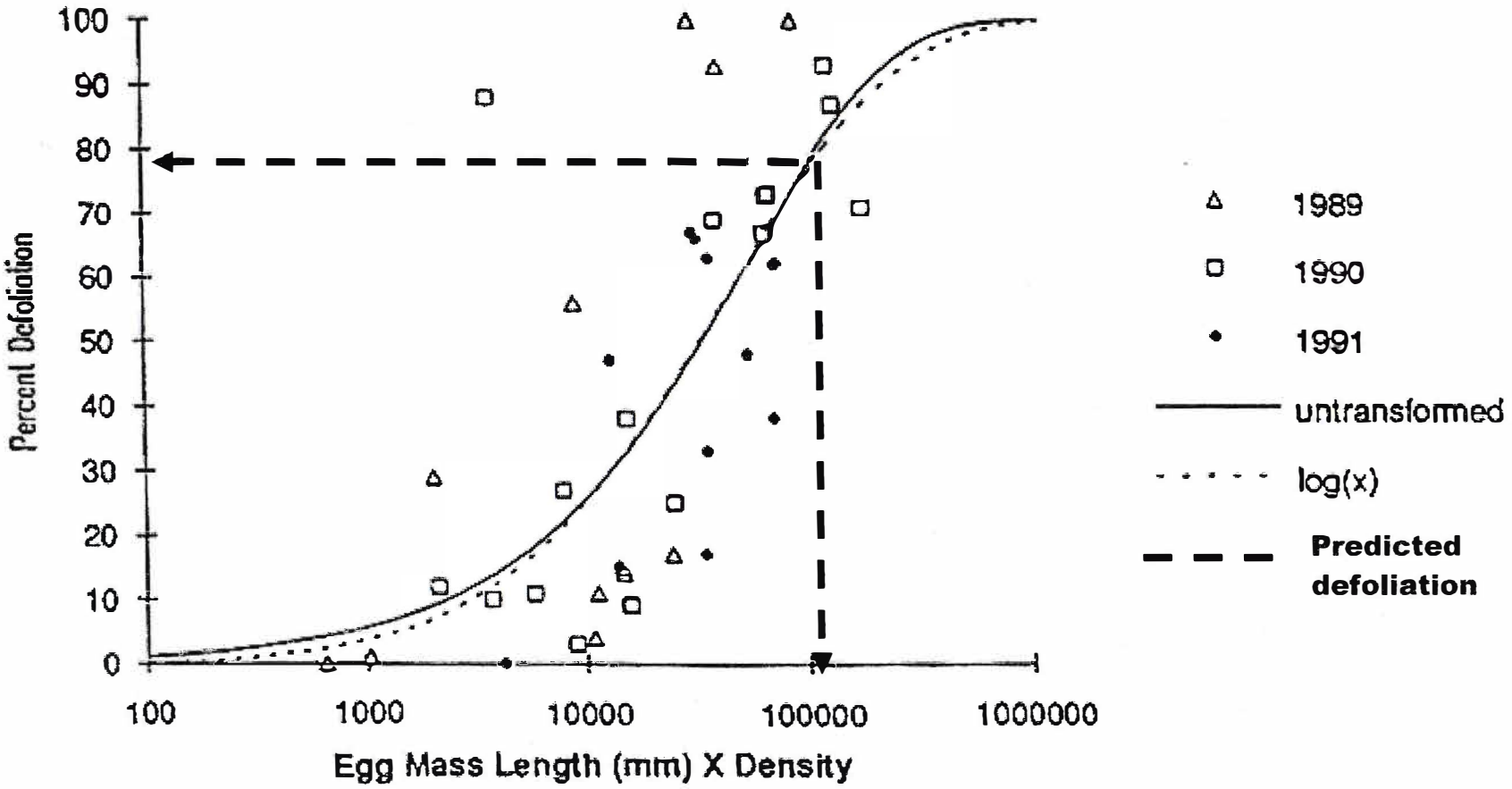


Figure 3.—Predicted defoliation in the area around the golf course at Andrews AFB in 2008.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3400
Date: October 5, 2007

Ms. Anne Kaval
316 CES/CEU
3466 North Carolina Avenue
Andrews Air Force Base, MD 20762-4802

Dear Ms. Kaval:

Enclosed is the gypsy moth biological evaluation for Andrews Air Force Base.

In brief, gypsy moth populations are sufficient to cause heavy defoliation on 215 acres. We are recommending a single application of Dimilin® (diflubenzuron). With good timing and proper application, gypsy moth defoliation should be minimal at Andrews Air Force Base in 2008.

Please contact me at 304-285-1555 if you have any questions regarding this gypsy moth biological evaluation.

Sincerely,

Rodney L. Whiteman

RODNEY L. WHITEMAN
Forester
Forest Health Protection

Enclosure

Cc: Robert Tichenor, MDA
Pete Egan, Armed Forces Board
Noel Schneeberger, AO
Robert Lueckel, MFO